PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G01S 5/14	A1	(11) International Publication Number: WO 98/09181
		(43) International Publication Date: 5 March 1998 (05.03.98)

(21) International Application Number: PCT/IB97/00788

(22) International Filing Date: 26 June 1997 (26.06.97)

(30) Priority Data:
9618067.4 29 August 1996 (29.08.96) GB

(71) Applicant: PHILIPS ELECTRONICS N.V. [NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven (NL).

(71) Applicant *(for SE only)*: PHILIPS NORDEN AB [SE/SE]; Kottbygatan 7, Kista, S-164 85 Stockholm (SE).

(72) Inventors: YULE, Andrew, Thomas; Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL). GIBSON, Rodney, William; Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL). YOUNG, Bryan, David; Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL).

(74) Agent: MOODY, Colin, J.; Internationaal Octrooibureau B.V., P.O. Box 220, NL-5600 AE Eindhoven (NL).

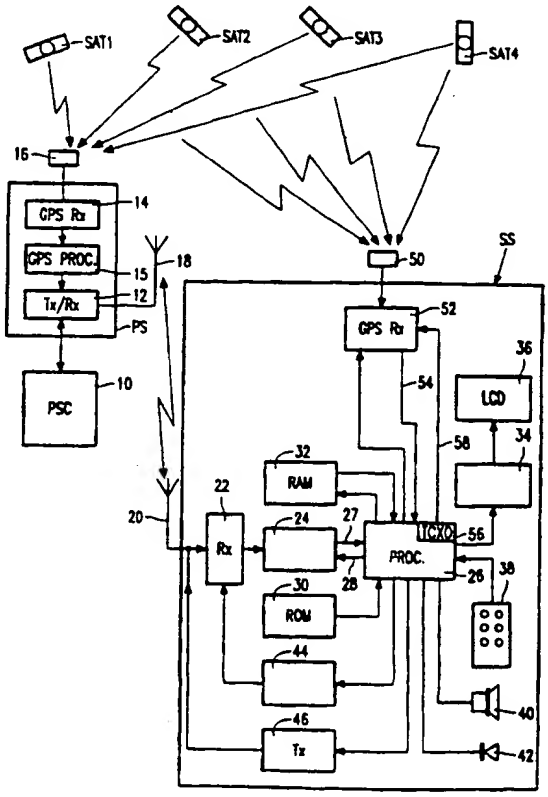
(81) Designated States: CN, JP, KR, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: COMBINATION OF A GPS RECEIVER AND A TELECOMMUNICATIONS APPARATUS

(57) Abstract

A combination of a GPS receiver (52) and a communications receiver (22) or transceiver (22, 46) which share a processor (26) in the communications receiver in order to handle normal communications traffic and to determine the position of the secondary station (SS). In order to reduce the acquisition time and current consumed by the secondary station (SS), a primary station (PS) of the communication system is also equipped with a GPS receiver (14) and digital baseband processor (15) for recovering at least the ephemeris data transmitted by orbiting GPS satellites (SAT1 to SAT4), the ephemeris data being down-loaded to the secondary station (SS) and stored in a memory (32) ready for use when a positional fix is required.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

DESCRIPTION

COMBINATION OF A GPS RECEIVER AND A TELECOMMUNICATIONS APPARATUS

The present invention relates to a combination of a GPS receiver and a telecommunications transceiver or receiver. A particular, but not exclusive, application of the present invention is a combination of a GPS receiver and an answer-back pager. However the latter may comprise a one way (or receive only) pager, a cellular/cordless telephone or a mobile/portable transceiver.

In the present specification the term GPS is to be understood to cover other satellite navigation systems as well as the Global Positioning System of the USA. Further, in the present specification the term "ephemeris data" has been used to describe all the data transmitted by a GPS satellite, which data characterises both the satellite's orbit and the characteristics of its on-board clock.

The English language abstract of Japanese Kokai 07075162 discloses a promotional apparatus for use with retail premises in which a transmitter transmits one way promotional information together with location information. A subscriber possessing a secondary station having a receiver for receiving the promotional information, a GPS receiver, CD-ROM and an LCD panel, all connected to a processor, is able to receive the promotional information and display the location of the retail premises together with the route from the subscriber's present location, as determined by the GPS receiver, to the retail premises using mapping information held on the CD-ROM.

In the known secondary station each of the receivers carries out its own function and supplies the results to the processor. This is not particularly effective from the point of view of battery current savings.

In order for the appropriate measurements to be made by the GPS receivers, that is, timing the arrival of signals from at least four GPS satellites,

the GPS receiver would need to be given a clear view of the sky for a period of approximately 10 seconds. Once the measurements have been taken, a calculation of the subscriber's position needs to be carried out and the result displayed by whatever means the secondary station has, normally a LCD screen. The time taken for this calculation will depend on the processing power of the microprocessor in the GPS receiver. As an indication a type 8051 processor requires approximately 5 seconds to carry out the necessary processing.

At present, the hardware required for a GPS receiver is typically made up of two integrated circuits, namely an analogue rf front end and a digital base band processor, with a small number of discrete components. The antenna is typically a simple patch antenna approximately 2 to 3 centimetres on each side (the carrier frequency is approximately 1.5 GHz). A typical present-day GPS chip set might consume 500 to 800 mW of power at 3 volts. There are a number of reasons for this high power consumption, but probably the main one is that for most current applications continuous operation is required with new position fixes being generated every second. This leads to the need for a power hungry 16 bit microprocessor clocked typically at 25 MHz.

The time taken for a GPS receiver to generate the position fix from the time it is turned on is governed by the following factors:

1. The time taken to acquire signals from enough (at least 4) GPS satellites

2. The time taken to down-load enough data from the acquired satellite to characterise their orbits and clock discrepancies.

3. The time taken to process the raw measurements and calculate the position.

The last of these is the easiest to characterise as it involves a fairly well defined set of calculations and thus is dependant on the processing power of the microprocessor in the receiver. As mentioned above, this leads to a fairly straightforward power versus speed trade-off. Current GPS chip sets use a processor powerful enough to carry out this step in less than a second, but if

the calculations were done on a smaller processor it may take nearer 10 seconds.

The first two factors are rather different in nature as they are issues that are normally not too important in GPS receivers. This is because they only have to be carried out at start-up and then occasionally as a background task. Acquiring at least four satellites is highly dependent on how much prior knowledge the system has. If it has no information whatsoever, the acquisition might take an hour, whilst if it has a good idea of its position (within a few 10s of kilometres) and the current time (within a few seconds) acquisition may take only a couple of seconds. In the limit, a receiver that knows very accurately where it is and what the time is, could acquire signals almost instantly. Most current GPS receivers store some crude satellite orbit parameters (good enough for a prediction over a period of a few weeks) in a non-volatile memory and maintain a real - time clock when they are turned off. As a consequence they can normally acquire satellites within 10 to 30 seconds of being turned on.

Down-loading suitable orbit data from the satellites in theory takes a minimum of thirty seconds. This is because the data is repeatedly transmitted in five sub-frames each of which takes 6 seconds to transmit. Of course, in practice, a GPS receiver may acquire the signal at any point during the transmission cycle, so a particular instance may "waste" nearly a whole six second sub-frame whilst trying to find a recognisable preamble. Again some current GPS receivers store this data whilst they are turned off. However, the data only has a valid lifetime of a few hours (the orbits of the satellites are not constant) and so storing it for more than a day or so would achieve little.

An object of the present invention is to economise on the power consumption of a secondary station for receiving and processing GPS signals.

According to one aspect of the present invention there is provided a combination of a paging system and a GPS system, comprising a primary station having a GPS receiver and processor for receiving and deriving at least ephemeris data from received GPS signals and at least one transmitter for

transmitting communication signals and the ephemeris data, and a secondary station having a GPS receiver, a communication receiver for receiving communication signals and ephemeris data from the at least one transmitter, a processor coupled to the GPS receiver and the communications receiver for determining the location of this secondary station from the ephemeris data and the GPS signals received by the GPS receiver.

By the transmitter in the primary station occasionally broadcasting GPS ephemeris data, the time taken, and thereby the power consumed, to carry out a GPS position fix can be reduced considerably thereby leading to a significant current saving.

According to a second aspect of the present invention there is provided a secondary station for use in a system in which a primary station broadcasts ephemeris data relating to orbiting GPS satellites, the secondary station comprising a GPS receiver, a communications receiver for receiving communication signals and ephemeris data from the at least one transmitter, a processor coupled to the GPS receiver and the communications receiver for determining the location of the secondary station using the ephemeris data and GPS signals received by the GPS receiver.

If desired a clock signal generated for the processor may be used to provide an accurate time signal to the GPS receiver and its digital baseband processor. The more accurately the GPS receiver knows the time, the easier it is for it to acquire the signal from the GPS satellite from the point of view of predicting the expected position in the sky and thus the determination of the Doppler shift is easier.

If desired a crystal controlled oscillator used by the processor may also be used to characterise the local oscillator of the GPS receiver in advance. This in turn reduces the degree of uncertainty when attempting to acquire signals from the GPS satellite.

If desired the secondary station may include a transmitter for transmitting location data to the primary station. In an emergency situation the transmitter can be used as an emergency beacon for transmitting the location data as a

relatively low-bit rate signal thereby enabling the signal to be detected over a larger area than would be possible with a higher bit-rate transmission. Optionally the secondary station may include coding means by which a user can send a coded signal indicating the type of emergency and/or what services are required at the same time as transmitting the location data.

The present invention will now be described, by way of example, with reference to the single figure of the accompanying drawings which shows an embodiment of an invention in which the secondary station comprises a GPS receiver and answer-back pager.

The infrastructure comprises a paging system controller (PSC) 10 connected by a landline to one of a plurality of primary stations PS. The primary station comprises a transceiver 12 which is controlled by the PSC 10. A GPS receiver 14 which has an antenna 16 coupled to its input, has an output coupled to a digital baseband processor 15 including storage means (not shown) for ephemeris data recovered from the orbiting GPS satellite SAT1, SAT2, SAT3 and SAT4.

Paging signals from the PSC 10 and the ephemeris data are transmitted by the transceiver 12 by way of an antenna 18.

A secondary station SS comprises an antenna 20 coupled to a receiver stage 22, the output of which is supplied to a decoder 24. A processor 26 is coupled by way of bi-directional links 27, 28 with the decoder 24. The processor 26 is operated in accordance with software held in a programme store 30. A RAM 32 for storing data messages and ephemeris data received from a primary station PS is coupled to the processor 26. The latter has an output coupled to a LCD driver 34 which in turn is coupled to a LCD panel 36. A keypad 38 is coupled to the processor to provide a man/machine interface. An acoustic transducer 40 and a light emitter 42, such as a LED, are coupled to the processor 26 which uses them as alerting devices and, additionally, the light emitter 42 may be used to forward optically messages and location data stored in the RAM 32 to say a printer or a personal computer (not shown). The

receiver 22 is operated by a processor 26 in accordance with a battery economising protocol and a battery economising stage 44 is coupled between the processor 26 and the receiver 22. A low-power transmitter 46 is coupled between an output of the processor 26 and the antenna 20.

A patch antenna 50 is coupled to a GPS receiver 52 which provides an output 54 to the processor 26 which uses the received satellite data and the ephemeris data stored in the RAM 32 to compute the location of the secondary station.

The processor 26 includes a clock circuit based on a temperature controlled crystal oscillator (TCXO) 56. The TCXO 56 provides an output 58 to the GPS receiver 52 in which it is used to characterise the receiver's local oscillator in advance. This removes uncertainty when attempting to acquire signals from the GPS satellites SAT1, SAT2, SAT3 and SAT4.

In operation, the PSC 10 causes paging signals to be transmitted according to any suitable protocol such as the CCIR Radiopaging Code No 1, otherwise known as POCSAG. Messages received and decoded by the secondary stage are stored in the RAM 32 for later recall and display.

Each GPS satellite (typically there are 24 in operation at any time) broadcasts approximately 500 bits of data detailing its orbit and information about its on-board clock, herein collectively termed the ephemeris data. This information is usually updated every hour but is deemed to be valid for four hours. Accordingly the ephemeris data need only be relayed infrequently to the secondary station and this can be done in quiet periods. However the advantages of the secondary station storing ephemeris data in the RAM 32 are significant because it is likely that a position fix can be achieved within 15 to 20 seconds, of which only the first 10 seconds will involve the GPS specific hardware being active (the rest of the time would be needed purely for the position calculation by the processor 26).

In order for the transmission of the ephemeris data to be recognised by a secondary station, it is transmitted as a message which is prefixed with an address code word recognisable by secondary stations having GPS receivers.

In addition, the communications portion of the secondary station (SS) provides a means for aiding the GPS receiver in a number of ways:

TCXO 56 provides an accurate (to a fraction of a second) time signal. The more accurately the GPS device knows the time, the easier it is for it to acquire the signal from the GPS satellite (predicting the expected position in the sky and thus the doppler shift is easier to determine).

The local oscillator offset can be characterised in advance by reference to the apparent frequency of the paging signal. This again removes uncertainty when attempting to acquire the signals from GPS satellite.

So called "Differential GPS" signals may be incorporated into the pager system. This is a scheme that involves fixed base stations (for example the primary station transmitter sites) measuring apparent inaccuracies in the GPS signals (caused by atmospheric effects as well as the US military's deliberate attempts to degrade the quality of the information). The details of these inaccuracies can be sent to any GPS receivers in the locality and used to improve the accuracy of fair position calculations. This can potentially lead to inaccuracy of better than 5 meters (rather than the normal 100 meters).

The transmitter 46 provides the secondary station with a two-way capability. In its simplest form the secondary station SS can operate as an emergency beacon transmitting location data as a relatively low-bit rate signal, perhaps as a spread spectrum signal. Additionally the processor 26 can include coding means (not shown) which in response to actuation of the keys of the keypad 38 can enable the transmitter to transmit a coded signal indicating the type of emergency and/or what services are required together with location data.

From reading the present disclosure, other modifications will be apparent to persons skilled in the art. Such modifications may involve other features which are already known in the design, manufacture and use of GPS and telecommunication systems and component parts thereof and which may be used instead of or in addition to features already described herein. Although claims have been formulated in this application to particular combinations of

features, it should be understood that the scope of the disclosure of the present application also includes any novel feature or any novel combination of features disclosed herein either explicitly or implicitly or any generalisation thereof, whether or not it relates to the same invention as presently claimed in any claim and whether or not it mitigates any or all of the same technical problems as does the present invention. The applicants hereby give notice that new claims may be formulated to such features and/or combinations of such features during the prosecution of the present application or of any further application derived therefrom.

CLAIMS

1. A combination of a paging system and a GPS system, comprising a primary station having a GPS receiver and processor for receiving and deriving at least ephemeris data from received GPS signals, at least one transmitter for transmitting communication signals and the ephemeris data, and a secondary station having a GPS receiver, a communication receiver for receiving communication signals and ephemeris data from the at least one transmitter, a processor coupled to the GPS receiver and the communication receiver for determining the location of the secondary station using the ephemeris data and GPS signals received by the GPS receiver.

2. A secondary station for use in a system in which a primary station broadcasts ephemeris data relating to orbiting GPS satellites, the secondary station comprising a GPS receiver, a communications receiver for receiving communication signals and ephemeris data from a primary station, a processor coupled to the GPS receiver and the communications receiver for determining the location of the secondary station using the ephemeris data and GPS signals received by the GPS receiver.

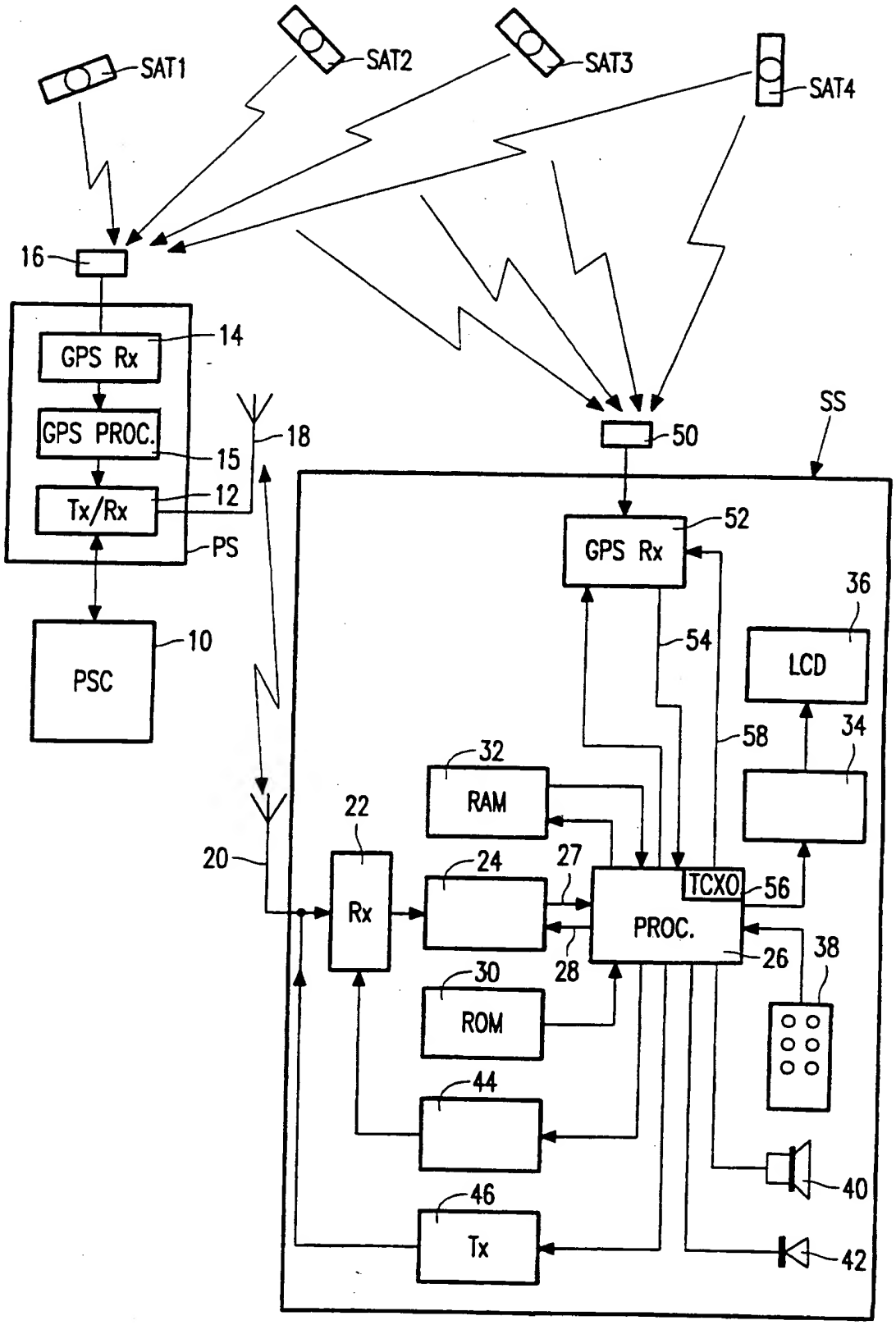
3. A secondary station as claimed in Claim 2, characterised in that the processor includes a clock signal generator for generating a clock signal, and in that the clock signal is supplied to the GPS receiver.

4. A secondary station as claimed in Claim 3, characterised in that a crystal controlled oscillator is used to generate the clock signal and in that the output of the crystal controlled oscillator is used to characterise the local oscillator of the GPS receiver in advance.

5. A secondary station as claimed in any one of Claims 2 to 4, characterised in that the secondary station includes a transmitter coupled to the

processor, said transmitter being used for transmitting location data.

6. A secondary station as claimed in Claim 5, characterised in that the processor includes coding means by which a user can send a coded signal giving additional information at the same time as transmitting the location data.


SAT1
SAT2
SAT3
SAT4
16
GPS Rx
14
GPS PROC.
15
Tx/Rx
12
18
PS
PSC
10
SS
50
GPS Rx
52
54
36
LCD
34
58
RAM
32
22
20
Rx
24
27
TCXO
56
PROC.
26
28
38
ROM
30
44
40
46
Tx
42

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 97/00788

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G01S 5/14
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: G01S

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 9622546 A1 (THE BOARD OF TRUSTEES OF THE LELAND STANFORD JUNIOR UNIVERSITY), 25 July 1996 (25.07.96), page 21, line 23 - page 22, line 4, figure 9	1,2
X	GB 2264837 A (KOKUSAL DENSHIN DENWA COMPANY LIMITED), 8 Sept 1993 (08.09.93), page 10, line 12 - page 13, line 2, figures 1,2	1,2,5
X	EP 0574009 A2 (TOKYO COSMOS CO., LTD.), 15 December 1993 (15.12.93), figure 1, abstract	1,2

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 January 1998	14 -01- 1998
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Göran Magnusson Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 97/00788

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 9521386 A1 (TRIMBLE NAVIGATION), 10 August 1995 (10.08.95), page 11, line 24 - page 15, line 2, figure 1	1,2

INTERNATIONAL SEARCH REPORT

Information on patent family members

02/12/97

International application No.
PCT/IB 97/00788

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9622546 A1	25/07/96	US 5621646 A	15/04/97
GB 2264837 A	08/09/93	JP 5232210 A	07/09/93
EP 0574009 A2	15/12/93	JP 5202826 A	10/08/93
		JP 9230025 A	05/09/97
		JP 2562803 B	11/12/96
		JP 6097304 A	08/04/94
WO 9521386 A1	10/08/95	NONE	